PATENT ABSTRACTS OF JAPAN

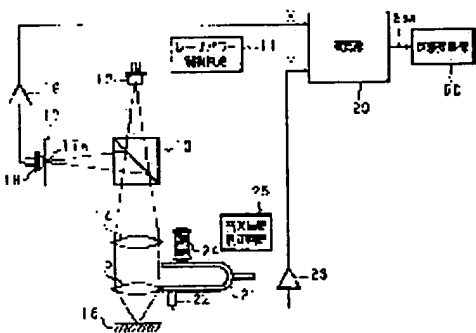(51)Int.CI.   G01B 11/06

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(54) DISPLACEMENT GAUGE AND DISPLACEMENT MEASURING METHOD, AND THICKNESS GAUGE

(57)Abstract:

PURPOSE: To measure the displacement on the surface of an object to be measured with no difference by projecting a light onto an object to be measured while an objective lens is shifted along a light axis and determining the position of the objective lens at the time when the focal point of the light is formed on the object.

CONSTITUTION: As an objective lens 15 is shifted along a light axis, the distance between the lens 15 and an object 16 to be measured varies. When it becomes equal to a predetermined distance, the focal point of the projected light onto the object 16 is formed on the object 16. Then only a reflecting light from the focal point position passes through a light-converging part 17. A photo-diode 18 receives it and the light-receiving quantity of the photo-diode 18 becomes the maximum. A signal corresponding to the light-receiving quantity is inputted into an amplifier 19 and further the amplifier 19 inputs an output signal X into a calculation part 20. The position of the lens 15 at the time of the maximum light-receiving quantity is correspondent to the distance between the reference point of an optical system and the object 16. The object 16 is shifted along the direction crossing a light axis at a right angle so as to measure the displacement on the surface of the object 16.

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CLAIMS

[Claim(s)]

[Claim 1] A displacement gage which is characterized by providing the following and with which a light-emitting part projects light which carried out outgoing radiation on a device under test through an objective lens, receives the reflected light from a device under test, and measures a variation rate of a front face of a device under test based on light income which received light The excitation section which vibrates said objective lens with predetermined amplitude A location detecting element which detects a location of an objective lens An optical converging section which the reflected light from a device under test passes A light sensing portion which receives light which passed along this optical converging section, a means to catch a detection position signal of said location detecting element at the maximum event of light income of said light sensing portion, and a means to ask for a variation rate of a front face of a device under test based on a caught detection position signal

[Claim 2] A displacement gage according to claim 1 constituted by tuning fork which connected an objective lens for said excitation section, and solenoid which drives this tuning fork.

[Claim 3] A tuning fork which connected said excitation section with an objective lens, and a displacement gage according to claim 1 constituted by mounting beam piezoelectric device to this tuning fork.

[Claim 4] A displacement gage according to claim 1 which connects an objective lens with the 1 side of a tuning fork of said excitation section, and has connected a collimate lens arranged on the same optical axis as said objective lens to a side besides a tuning fork.

[Claim 5] A displacement gage according to claim 1 which forms said optical converging section by pinhole, and is constituted.

[Claim 6] A displacement gage according to claim 1 which constitutes said optical converging section by slit.

[Claim 7] The displacement-measurement method characterized by to detect the location of the objective lens which vibrated the objective lens which light projected to a device under test passes in a method of receiving the reflected light of light projected to a device under test, and measuring a variation rate of a front face of a device under test in the direction of said light of an optical axis, and vibrated it, to catch the location of an objective lens at the quantity of light maximum event of the reflected light from a device under test, and to ask for the variation rate of the front face of a device under test based on the location which caught.

[Claim 8] A thickness meter characterized by providing the following A light-emitting part which carries out outgoing radiation of the light to a device under test An objective lens which said light passes The excitation section which vibrates this objective lens A location detecting element which detects a location of said objective lens, a light sensing portion which receives the reflected light from a device under test, a means to catch a detection position signal of said location detecting element when [each] the maximal value of light income of said light sensing portion got mixed up and arises, and a means to ask for thickness of a device under test based on a caught detection position signal

[Claim 9] A thickness meter according to claim 8 constituted by solenoid which drives a tuning fork which connected said excitation section with an objective lens, and this tuning fork.

[Claim 10] A thickness meter according to claim 8 constituted by mounting beam piezoelectric device to a tuning fork which connected said excitation section with an objective lens, and this tuning fork.

[Claim 11] A thickness meter according to claim 8 which connects an objective lens with the 1 side of a tuning fork of said excitation section, and has connected a collimate lens arranged on the same optical axis as said objective lens to a side besides a tuning fork.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention projects light on the front face of device under tests, such as a metal, resin, paper, and a ceramic, and relates to the thickness meter which measures the thickness of a device under test using the displacement gage which measures the variation rate of the front face of a device under test and the displacement measurement method, and the same measurement principle.

[0002]

[Description of the Prior Art] For example, the focus inspection appearance type non-contact displacement gage is used for the equipment which measures the variation rate of the front face of device under tests, such as a metal and resin. drawing 14 -- a journal "opto-electronics contact Vol.26 and No.11 (1988)" -- the 775th Foucault shown in the page -- it is the typical block diagram of the focus inspection appearance type non-contact displacement gage by law. It is projected on the outgoing radiation light of a laser diode 1 to a device under test 5 through a collimate lens 2, the light wave division prism 3, and an objective lens 4.

[0003] The reflected light from a device under test 5 is the photo diodes 7a and 7b of each which passes along the light wave division prism 6, and detects the focusing point's of the light projected on the device under test 5 after reflecting by the light wave division prism 3 2 division. Incidence is carried out. Photo diodes 7a and 7b The electrical signal by which photo electric translation was carried out is inputted into the differential amplifier 8. The control section 9 consists of lens positioning-control-circuit 9a, data-processing circuit 9b, and display circuit 9c,

and the output signal of the differential amplifier 8 is inputted into lens positioning-control-circuit 9a. the electromagnetism whose control signal outputted from lens positioning-control-circuit 9a is made to lower-** an objective lens 4 in the direction of an optical axis a top -- it is given to a coil 10.

[0004] Next, actuation of this non-contact displacement gage is explained. If light is projected from a laser diode 1 to a device under test 5, it reflects by the light wave division prism 3, and the reflected light from a device under test 5 is photo diodes 7a and 7b. Incidence is carried out. If the distance of an objective lens 4 and a device under test 5 changes here, the angle of divergence of the reflected light bunch from a device under test changes, and they are photo diodes 7a and 7b. A difference arises in light income. And the signal according to the difference of light income is outputted from the differential amplifier 8, and it is inputted into lens positioning-control-circuit 9a. And when the focusing point of the outgoing radiation light from a laser diode 1 arises in a device under test 5, they are photo diodes 7a and 7b. Each light income becomes equal and the output signal of the differential amplifier 8 is extinguished.

[0005] Thus, photo diodes 7a and 7b It will be detected whether the focusing point of the light in which the laser diode 1 carried out outgoing radiation based on light income has arisen in the device under test. then, photo diodes 7a and 7b a focusing point arises in a device under test so that light income may become equal that is, -- as -- the control signal from lens positioning-control-circuit 9a -- electromagnetism -- if a coil 10 is driven and the location of an objective lens 4 is made to lower-** a top, the controlled variable which moves an objective lens up and down will be equivalent to the variation rate of the front face of a device under test, and will have measured the variation rate of the front face of a device under test with the controlled variable.

[0006]

[Problem(s) to be Solved by the Invention] However, when the so-called unlicensed light with which the light projected on ** et al. and a device under test 5 is hidden in the interior of a device under test 5 occurs It will dive into the front face of a device under test 5, the flare of the light of the three dimension by light will arise, and they are two photo diodes 7a and 7b. Each will receive the light which the focusing point has produced, and the light which has spread by unlicensed light, and is photo diodes 7a and 7b. A difference arises in light income.

[0007] It is projected on the stray light near the location which the focusing point has produced on the front face of a device under test 5 on the other hand when the stray light has occurred within a laser diode 1 apart from it, therefore they are two photo diodes 7a and 7b. The light which the focusing point has produced, and the light by the stray light are received, and they are photo diodes 7a and 7b also in this case. A difference arises in light income. Therefore, when an unlicensed light or the stray light has arisen, even if the focusing point of the light in which the laser diode 1 carried out outgoing radiation has arisen in the device under test 5, they are two photo diodes 7a and 7b. Light income does not become equal but the problem that an error arises is in the value which measured the variation rate of the front face of a device under test 5.

[0008] This invention aims at offering the thickness meter using the displacement gage which can measure the variation rate of the front face of a device under test without error and the displacement measurement method, and the same measurement principle, when it dives into a device under test and light has arisen in view of this problem, or even when the stray light has arisen in the laser diode.

[0009]

[Means for Solving the Problem] In a displacement gage which a displacement gage concerning the 1st invention projects light in which a light-emitting part carried out outgoing radiation on a device under test through an objective lens, receives the reflected light from a device under test, and measures a variation rate of a front face of a device under test based on light income which received light The excitation section which vibrates said objective lens with predetermined amplitude, and a location detecting element which detects a location of an objective lens, An optical converging section which the reflected light from a device under test passes, and a light sensing portion which receives light which passed along this optical converging section, It is characterized by having a means to catch a detection position signal of said location detecting element at the maximum event of light income of said light sensing portion, and a means to ask for a variation rate of a front face of a device under test based on a detection position signal which caught.

[0010] In a method of a displacement measurement method concerning the 2nd invention receiving the reflected light of light projected to a device under test, and measuring a variation rate of a front face of a device under test A location of an objective lens which vibrated an objective lens which light projected to a device under test passes in the direction of an optical axis of said light, and vibrated it is detected, and it is characterized by asking for a variation rate of a front face of a device under test based on a location which caught and caught a location of an objective lens at the quantity of light maximum event of the reflected light from a device under test.

[0011] A light-emitting part with which a thickness meter concerning the 3rd invention carries out outgoing radiation of the light to a device under test, and an objective lens which said light passes, The excitation section which vibrates this objective lens, and a location detecting element which detects a location of said objective lens, It is characterized by having a light sensing portion which receives the reflected light from a device under test, a means to catch a detection position signal of said location detecting element when [each] the maximal value of light income of said light sensing portion got mixed up and arises, and a means to ask for thickness of a device under test based on a caught detection position signal.

[0012]

[Function] In the 1st invention, if an objective lens is vibrated with the predetermined amplitude in the direction of an optical axis, the distance of an objective lens and a device under test will change. When an objective lens and a device under test reach predetermined distance, the focusing point of the light projected to the device under test arises in a device under test. It is projected on the reflected light from a device under test to an optical converging section, and the reflected light produced in the device under test by unlicensed light and the stray light is interrupted. And

only the reflected light from the focusing point location which the focusing point has produced passes an optical converging section, a light sensing portion receives it, and the light income of a light sensing portion becomes max. And the location of the objective lens at the time of light income becoming max corresponds to the distance from the criteria location of optical system to a device under test. If a device under test is moved in the direction which intersects perpendicularly with an optical axis, the variation rate of the front face of a device under test can be measured. Thereby, the variation rate of the front face of a device under test can be measured with the location of the objective lens at the maximum event of light income. Since the reflected light by unlicensed light and the stray light is interrupted by the optical converging section, a variation rate can be measured without error.

[0013] In the 2nd invention, as shown in drawing 1 , the outgoing radiation light from a laser diode C is projected on a device under test B through a beam splitter D, a collimate lens L, and objective lens A. If objective lens A is vibrated in the direction of an optical axis shown by the arrow mark with the predetermined amplitude, the location of objective lens A will change like the curve Q shown in drawing 2 . And the distance of objective lens A and a device under test B changes. It reflects by the beam splitter D and incidence of the reflected light from a device under test B is carried out to a light sensing portion E through optical converging section F. Whenever the focusing point of the light projected on the device under test B arises twice on a device under test B and a focusing point arises in 1 period of an oscillation of objective lens A, the light income of a light sensing portion E becomes max. That is, when objective lens A and a device under test B become predetermined distance, a focusing point arises on a device under test B.

[0014] Then, before objective lens A carries out a closest approach to a device under test B when light is projected on the height location low [the] noting that the variation rate (height) of the front face of a device under test B is a high, inside, and low three-stage, a focusing point arises in a device under test B at next each event, and the light income of a light sensing portion E serves as max, and it is drawing 3 (a). The focus inspection appearance signals Z and Z occur so that it may be shown. Moreover, a focusing point arises in a device under test B at the event of objective lens A carrying out a closest approach to a device under test B, when light is projected on the inner height location, and the medium event with the event of maximum-deserting, the light income of a light sensing portion E serves as max, and it is drawing 3 (b). The focus inspection appearance signals Z and Z occur so that it may be shown. Furthermore, when light is projected on the high height location, before objective lens A maximum-deserts a device under test B, at next each event, a focusing point arises in a device under test B, and the light income of a light sensing portion E serves as max, and it is drawing 3 (c). The focus inspection appearance signals Z and Z occur so that it may be shown. Thereby, the location of objective lens A at the time of the focus inspection appearance signals Z and Z occurring, i.e., the amplitude of objective lens A, corresponds to the distance from the criteria location of optical system to a device under test, and if a device under test B is moved in the direction which intersects perpendicularly with an optical axis, the variation rate of the front face of a device under test B can be measured.

[0015] In the 3rd invention, if an objective lens is vibrated with the predetermined amplitude in the direction of an optical axis, the distance of an objective lens and a device under test will change. The light projected on the device under test by each of both sides of the device under test which has countered with the objective lens that a device under test is tabular [of translucency] reflects strongly, the maximal value of the light income of a light sensing portion gets mixed up, and it is generated twice. The detection position signal in relation to the location of the objective lens at the time of [each] the maximal value of light income getting mixed up, and being generated twice corresponds to the distance from the criteria location of optical system to each of both sides of a device under test. The difference of the detection position signal in relation to the location of the objective lens at the time of [each] the maximal value of light income getting mixed up and arising corresponds to the thickness of a device under test. Thereby, the thickness of a device under test can be measured from the difference of a detection position signal.

[0016]

[Example] This invention is explained in full detail below with the drawing in which the example is shown. Drawing 4 is the typical block diagram of the displacement gage concerning this invention. The outgoing radiation light of the laser diode 12 driven in the laser power control circuit 11 carries out sequential passage of a beam splitter 13, and a collimate lens 14 and an objective lens 15, and it is projected on it by the device under test 16. It reflects by the beam splitter 13 through an objective lens 15 and a collimate lens 14, and the reflected light from a device under test 16 is pinhole 17a. Pinhole 17a of the optical converging section 17 currently formed It passes and incidence is carried out to photo diode 18. Pinhole 17a Magnitude phi is selected in order to make in a minute path as much as possible by the degree type. The wavelength of the light of a phi=0.61x laser diode / NA -- (1), however NA, i.e., numerical aperture, are the constant [0017] shown according to optical system. The signal which carried out photo electric translation with photo diode 18 is inputted into amplifier 19, and the output signal X is inputted into operation part 20. The periphery portion of an objective lens 15 is attached at the head of 1 side length **** of the tuning fork 21 which carried out the shape of U character. An objective lens 15 is vibrated by oscillation of a tuning fork 21 with the predetermined amplitude in the direction of an optical axis of the outgoing radiation light of a laser diode 12. The location detecting-element slack tuning fork amplitude detector 22 which consists of a sensor using the MAG, light, or electrostatic capacity is arranged in the side by the side of the head of 1 side length **** of a tuning fork 21, and the amplitude of a tuning fork 21, i.e., the location of an objective lens 15, is detected. The detection amplitude signal which the tuning fork amplitude detector 22 detected is inputted into amplifier 23, and the output signal Y is inputted into operation part 20. The solenoid 24 for vibrating a tuning fork 21 is arranged in the side by the side of the head of side length **** besides a tuning fork 21.

[0018] The control current from the tuning fork amplitude-control circuit 25 is supplied to a solenoid 24, and it is controlled so that the output signal of amplifier 23 may be given to the tuning fork amplitude-control circuit 25 and it may make the amplitude of a tuning fork 21 uniformly. In addition, for a tuning fork 21, 800Hz

and the amplitude are **0.3mm. It vibrates. The displacement signal outputted by catching by operation part 20 is inputted into the distance transform section 50.

[0019] Drawing 5 is the block diagram showing the configuration of operation part 20. Amplifier 19 (refer to drawing 4) inputted into operation part 20 An output signal X is inputted into a differentiator 30 and plus input terminal + of the 1st comparator 31. In negative input terminal - of a comparator 31, it is reference voltage Vref. It is inputted. The output signal S30 of a differentiator 30 is inputted into negative input terminal - of the 2nd comparator 32. Plus input terminal + of a comparator 32 is grounded. Comparators 31 and 32 Output signals S31 and S32 are AND. It is inputted into the 1 side input terminal of a circuit 33, and the side input terminal else at each **, and the output signal S33 is inputted into the single shot pulse generating circuit 34. The single shot pulse S34 which the single shot pulse generating circuit 34 outputs is given as ON and an off control signal to Switch SW.

[0020] amplifier 23 (refer to drawing 4) from -- an output signal Y is inputted into amplifier 36 through amplifier 35 and Switch SW. The input side of amplifier 36 is grounded through the capacitor 37. Amplifier 36 and a capacitor 37 constitute the sample hold circuit 38, and the displacement signal S38 is outputted from amplifier 36.

[0021] Next, actuation of the displacement gage constituted in this way is explained. If current is supplied to a solenoid 24 from the tuning fork amplitude-control circuit 25, a magnetic field will occur by the solenoid 24. A tuning fork 21 vibrates with the predetermined amplitude by this generating magnetic field, and an objective lens 15 is vibrated in the direction of an optical axis of the light which passes along it. The tuning fork amplitude detector 22 detects the amplitude of a tuning fork 21, i.e., the amplitude of an objective lens 15, and outputs the amplitude slack sine wave signal of an objective lens 15. This sinusoidal signal is amplified with amplifier 23, and the output signal Y outputted from amplifier 23 is made to input into operation part 20.

[0022] On the other hand, if actuation current is supplied to a laser diode 12 from the laser power control circuit 11, a laser diode 12 will carry out outgoing radiation of the laser beam. It is projected on this outgoing radiation light to a device under test 16 through a beam splitter 13, a collimate lens 14, and an objective lens 15. It reflects by the beam splitter 13 through an objective lens 15 and a collimate lens 14, and is projected to the optical converging section 17 side, and the reflected light reflected by the device under test 16 is pinhole 17a. Only a transmitted light carries out incidence to photo diode 18. Therefore, the reflected light by the stray light which was produced in the device under test 16 in photo diode 18, under which it went and which was generated with light and a laser diode 12 is pinhole 17a. It is interrupted and is pinhole 17a. It will not pass but only the light of the focusing point produced in the device under test 16 will carry out incidence to photo diode 18.

[0023] By the way, since the objective lens 15 is vibrated, when the distance of an objective lens 15 and a device under test 16 changes and predetermined distance is reached When the focusing point of the light projected on the device under test 16 arises in a device under test 16, it becomes max in an instant, the signal according

to this light-receiving output is inputted into amplifier 19, and the light-receiving output of photo diode 18 is drawing 6 (a) from amplifier 19. The shown output signal X is outputted and it is inputted into operation part 20.

[0024] Thus, when an output signal X and an output signal Y are inputted into operation part 20, it differentiates with a differentiator 30 and an output signal X is drawing 6 (b) from a differentiator 30. The output signal S30 of a differential wave which carried out the shape of reverse of S characters as shown is outputted. And the maximum of an output signal X is T0 at the zero cross event of an output signal S30. It will be detected and the event of the focusing point of the light projected on the device under test 16 arising will be detected to accuracy. This output signal S30 is inputted into a comparator 32, a comparator 32 carries out the size comparison of an output signal S30 and the touch-down potential, and it is T0 from a comparator 32 at the zero cross event of an output signal S30. Drawing 6 of the pulse width corresponding to [start and] the period of the negative half period of an output signal S30 (d) The output signal S32 of the shown pulse is outputted.

[0025] On the other hand, a comparator 31 is an output signal X and reference voltage Vref. A size comparison is carried out and a comparator 31 to the output signal X is reference voltage Vref. The output signal S31 shown in drawing 6 (c) of the pulse width corresponding to the period which is above is outputted. It is AND if the logic of these output signals S31 and S32 is materialized. A circuit 33 to drawing 6 (e) The output signal S33 of the shown pulse is outputted, and it inputs into the single shot pulse generating circuit 34. Thereby, the single shot pulse generating circuit 34 is drawing 6 (f) which starts synchronizing with the standup of an output signal S33. The shown single shot pulse S34 is outputted. And Switch SW is made to turn on by this single shot pulse S34.

[0026] If it does so, the output signal Y of the amplifier 35 which amplified the output signal Y is inputted into a sample hold circuit 38 through Switch SW, and a sample hold circuit 38 will sample and hold the signal level of an output signal Y, will amplify it with amplifier 35, and will output the displacement signal S38. This will sample the level of the output signal Y at the zero cross event of an output signal S30, i.e., the amplitude of an objective lens 15. And the sampled displacement signal S38 is inputted into the distance transform section 50, the displacement signal S38 is changed into the distance according to the displacement signal S38, and the variation rate of the front face of a device under test 16 is measured.

[0027] Drawing 7 is the timing chart of an output signal Y, the single shot pulse S34, and the displacement signal S38. As mentioned above, it is the location of an objective lens 15. (amplitude) As it corresponded and was shown in drawing 7 (a), while the output signal Y was changing, when the focusing point arose in the device under test 16, it is drawing 7 (b). Generating of the shown single shot pulse S34 samples the level of the output signal Y at the event. And when a device under test 16 is moved in the direction which intersects perpendicularly with an optical axis, it responds to the variation rate of the front face of a device under test 16, and the displacement signal S38 is drawing 7 (a). It changes stair-like so that it may be shown, and the level of the displacement signal S38 and the variation rate of the front face of a device under test 16 correspond. Therefore, if the level of an output

signal Y is sampled, according to the level of an output signal Y, the variation rate of a device under test 16 can be measured to high degree of accuracy.

[0028] Moreover, an objective lens 15 is vibrated, and since the level of the output signal Y at the time of a focusing point arising is sampled and the variation rate of the front face of a device under test 16 is measured, the variation rate can be measured at high speed.

[0029] Drawing 8 is the block diagram showing other configurations of operation part 20. An output signal X is the peak detecting signal SP which is inputted into the peak detector 40 and outputted from the peak detector 40. It is inputted into the 1st counter 41 and the counted value is inputted into an arithmetic circuit 42. On the other hand, an output signal Y is the zero cross detecting signal S0 which was inputted into the zero cross detector 43 and detected the zero cross. It is given to the 1st counter 41 and 2nd counter 44. The counted value of a counter 44 is inputted into an arithmetic circuit 42.

[0030] And the result-of-an-operation slack phasing signal S42 is outputted from an arithmetic circuit 42, and it is inputted into the distance transform section 50. The counter 41 is equipped with the latch section, can latch counted value twice, and is the zero cross detecting signal S0. Counted value is cleared. The counter 44 is equipped with the latch section, can latch counted value once, and is the zero cross detecting signal S0. Counted value is cleared.

[0031] Next, about actuation of the displacement gage at the time of using the operation part constituted in this way, they are an output signal Y and the peak value detecting signal SP. And zero cross detecting signal S0 It explains with drawing 9 which shows a timing chart. Drawing 9 according to the location (amplitude) of now and an objective lens (a) When the shown output signal Y is inputted into the zero cross detector 43, the zero cross event of an output signal Y is detected, and it is drawing 9 (c) from the zero cross detector 43. Shown zero cross detecting signal S0 It is outputted. Thereby, they are counters 41 and 44. Counted value is cleared, it continues and they are counters 41 and 44. Count actuation is started and time amount is counted. And a counter 44 is the 1st zero cross detecting signal S0. The event of being given to 2nd zero cross detecting signal S0 The time amount t3 of the event of being given, i.e., time amount of one period of an output signal Y, It counts and the counted value is made to latch to the latch section.

[0032] The output signal X acquired on the other hand when a focusing point arises in a device under test 16 detects the peak value of an output signal X, and peak detector 40 input **** and the peak detector 40 are the peak detecting signal SP. It outputs and inputs into a counter 41. Thereby, a counter 41 is the 1st peak detecting signal SP. The counted value t1 of the event of being inputted is made to latch to the latch section of a counter 41. 2nd [further] peak detecting signal SP Counted value t2 of the event of being inputted It is made to latch to the latch section of a counter 41. Thus, the latched counted value t1, t2, and t3 It inputs into an arithmetic circuit 42. the counted value t1 into which the arithmetic circuit 42 was inputted by that cause, t2, and t3 sin-1 (t1 / t3) -- and -- sin-1 (t2 / t3) -- calculating -- peak detecting signal SP The phase of the output signal Y at the output event is computed.

[0033] Thus, the phase of the computed output signal Y is equivalent to the level

of the output signal Y at the time of a focusing point arising in a device under test 16, i.e., the location of an objective lens 15. and the phasing signal S38 which is the result of an operation -- operation part 20 (arithmetic circuit 42) from -- it is outputted, is inputted into the distance transform section 50, it changes into distance, and the variation rate of the front face of a device under test 16 is measured. Thus, even if it asks for the phase of the output signal Y at the time of detecting the peak value of an output signal X, the variation rate of the front face of a device under test 16 can be measured.

[0034] In addition, it is pinhole 17a about the reflected light from a device under test 16. When it penetrates and incidence is carried out to photo diode 18 Even if the flare of light has arisen in the optical projection location of a device under test 16 by unlicensed light or the stray light Only a strong light when a focusing point arises carries out incidence to photo diode 18, by the reflected light by unlicensed light and the stray light, the light-receiving output of photo diode 18 does not change, and the variation rate of the front face of a device under test can be measured, without giving an error.

[0035] Next, the light projected on the glass plate when a glass plate was used for a device under test 16 is the output signal X1 with high peak value, and X2, as it reflects with the front face and rear face of an objective lens 15 and the glass plate which has countered and is shown in drawing 10. It gets mixed up, and it is obtained and is inputted into operation part 20. When the circuit shown in <u>drawing 8</u> is used for operation part 20 here, it is an output signal X1 and X2. The thickness of a glass plate can be measured by computing the phase contrast by calculating the phase of the output signal Y at the time of detecting peak value, respectively. However, output signal X2 corresponding to the light reflected with the rear face since the refractive index of a glass proper existed in the glass plate Since **** behavior of whether the thickness of a glass plate is thinner than actual thickness is carried out, if it amends using the refractive index n of glass, the thickness of a glass plate can be measured to accuracy.

[0036] And such an output signal X1 and X2 It is obtained almost simultaneously in the predetermined amplitude location of an output signal Y. Then, as the counter 44 in <u>drawing 8</u> shows to drawing 10, it is the time amount t0 of one period of an output signal Y. It counts. On the other hand, with a counter 41 1st output signal X1 Time amount t11 of a maximal value event to the zero cross event of an output signal Y, A zero cross event to 2nd output signal X2 The time amount t12 to a pole Hirotoki point 1st output signal X2 which counts or is generated just before [at the following zero cross event] from a zero cross event Time amount t13 to a pole Hirotoki point, 2nd output signal X1 generated immediately after [at the zero cross event] The time amount t14 to a pole Hirotoki point is counted and latched, and those counted value t0, and t11, t12, t13 and t14 are used. By the degree type An output signal X1 and X2 The phase of the output signal Y corresponding to an output event and its phase contrast are computed, the computed phase contrast is multiplied by the refractive index n, and a phase contrast signal is acquired.

$$\{\sin^{-1}(t12/t0) - \sin^{-1}(t11/t0)\} \times n \;\; \text{--} \;\; (2) = \{\sin^{-1}(t13/t0) - \sin^{-1}(t14/t0)\} \times n \;\; \text{--} \;\; (3)$$

[0037] And the phase contrast signal which shows the computed phase contrast is inputted

into the distance transform section 50, it changes into the distance corresponding to a phase contrast signal, and the thickness of the device under test 16 of translucency can be measured. In addition, an output signal X1 and X2 Since the amplitude is supported, the phase of the output signal Y corresponding to an output event is an output signal X1 and X2. Even if it computes the difference of the amplitude by catching the amplitude of the output signal Y at the output event, the thickness of a device under test can be measured similarly.

[0038] Drawing 11 is the block diagram showing other examples of the excitation section. The piezoelectric device CM is fixed to the lateral surface of 1 side length **** of a tuning fork 21, and each lateral surface of side length **** else, and a tuning fork 21 can be vibrated by impressing voltage to this piezoelectric device CM.

[0039] Drawing 12 is the block diagram of the example of further others of the excitation section. The periphery portion of an objective lens 15 is attached at the head of 1 side length **** of a tuning fork 21, and the periphery portion of the collimate lens 14 arranged on the same optical axis as an objective lens 15 is attached at the head of side length **** else. And it is making as [vibrate / both the objective lens 15 and the collimate lens 14]. If it does in this way, the weight of 1 side length **** of a tuning fork 21 and side length **** else may be equilibrated, and a tuning fork can be made to shake efficiently.

[0040] Drawing 13 is the block diagram of other examples of the optical converging section 17. Slit SLT established in the shape of a straight line by predetermined length It has become and is Slit SLT. Aperture width is pinhole 17a. It is formed in a diameter and ******. Such a slit SLT Although the reflected light from a device under test passes in an excess a little and the light-receiving engine performance of a light sensing portion falls slightly when it uses, positioning at the time of the assembly for letting the specific reflected light of a device under test pass becomes easy.

[0041]

[Effect of the Invention] Since according to the 1st invention an objective lens is vibrated in the direction of an optical axis, the location of the objective lens at the time of the focusing point of the light projected on the device under test arising on a device under test is caught and the variation rate of the front face of a device under test is measured as explained in full detail above, a variation rate can be measured at high degree of accuracy and high speed. Moreover, since the optical converging section is used, even if the reflected light by an unlicensed light and the stray light which are produced in a device under test has arisen, the displacement gage which an error does not produce in the measured value of a variation rate is obtained.

[0042] According to the 2nd invention, the outgoing radiation light of a light-emitting part is projected on a device under test through an objective lens, an objective lens is vibrated in the direction of an optical axis, the location of the objective lens at the time of the focusing point of the light projected on the device under test arising on a device under test is caught, and since the variation rate of the front face of a device under test is measured with the caught location, high degree of accuracy and the displacement measurement method which can be measured at high speed can be

offered for a variation rate.

[0043] The detection position signal relevant to the location of the objective lens at the time of [each] according to the 3rd invention, vibrating an objective lens in the direction of an optical axis, and the reflected light from each of both sides of a device under test tabular by the objective lens and the translucency which has countered getting mixed up, and being generated twice is caught, and the effect from which the thickness meter which can measure the thickness of a device under test is acquired according to the difference of the caught detection position signal and which was excellent in ** is done so.